

A hierarchical, synoptic, and dynamic seascape framework for observing and understanding biodiversity patterns in marine ecosystems

21 May, 2019

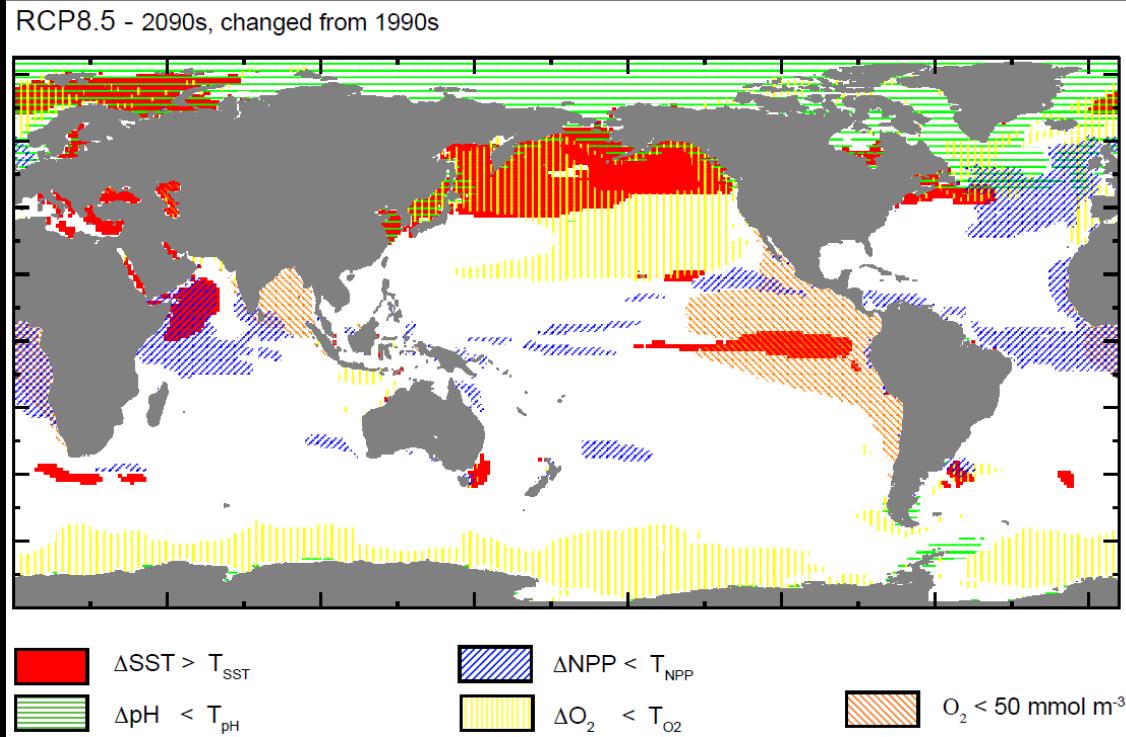
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Roger Sayre, Russ Hopcroft, Cheryl Hopcroft, Joaquin Trinanes, Jarrod Santora, Willem Klabjor

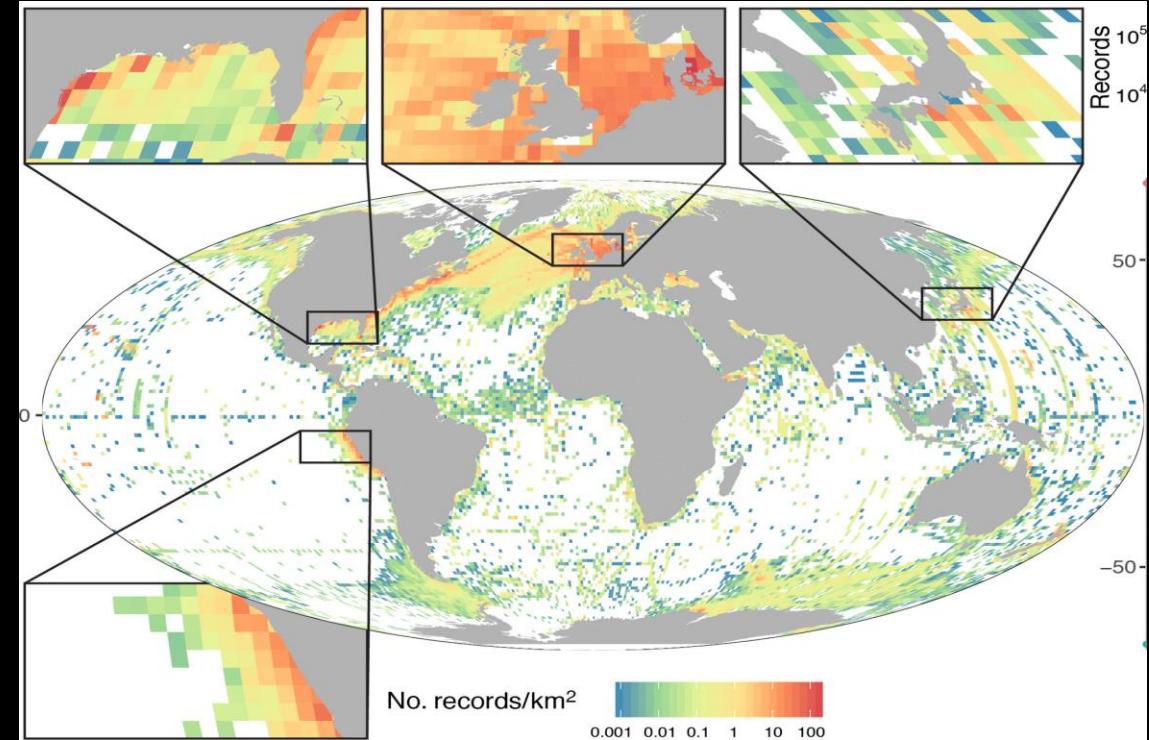


Motivation



Changing climate, upstream
land-use, fishing
Stressors: patchy and overlap

Figure: Bopp et al., 2013



Effects on abundances, ranges, and
connectivity require a baseline.
>10 M records, but inconsistent
and sparse coverage

Figure: Muller Karger et al., 2018

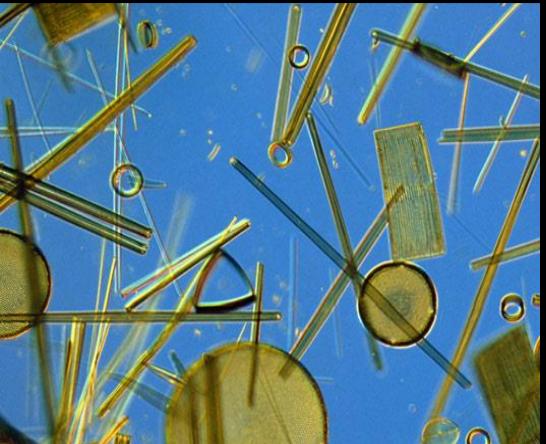
Seascape vs. Landscape Ecology

Land

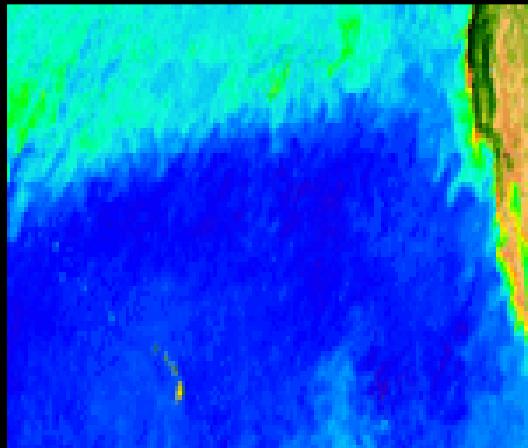
Primary Producers
(macro v. micro)



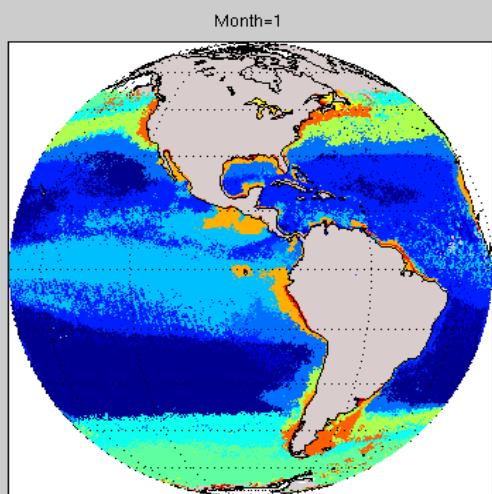
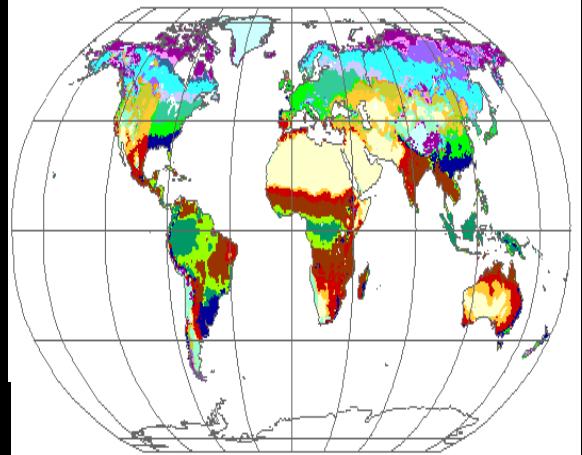
Sea



Time
(persistent v. ephemeral)

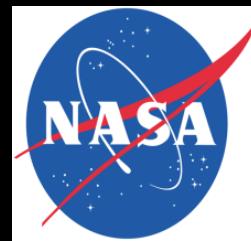


Boundaries
(static, strong v. dynamic, diffuse)



Pelagic seascape ecology : framework to relate organisms to dynamic habitat for a global marine biodiversity observing network

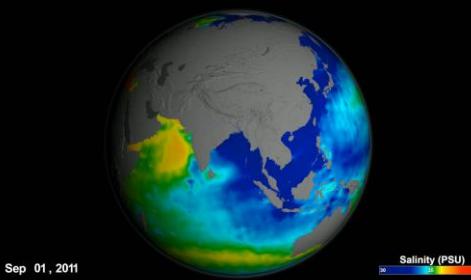
GEO BON



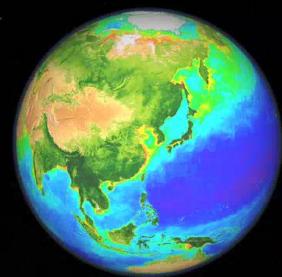
Multiplatform Integration

Machine Learning:

Satellite remote sensing,
ecosystem models



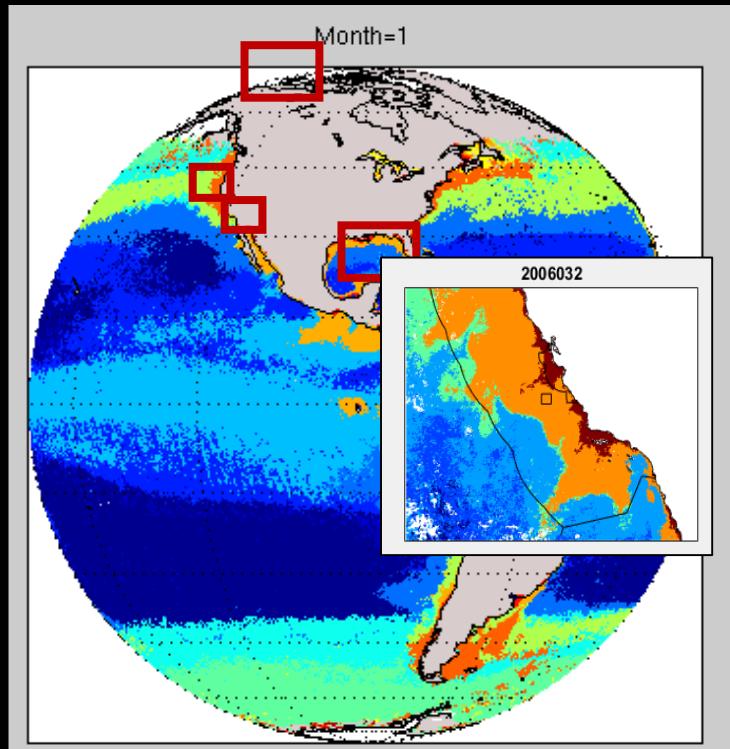
Physics: e.g.
SSS, SST, winds, SSHa



Biology:
Chl-a, nFLH, CDOM

EBV: Dynamic Extent

Seascape Classification/Prediction



Hierarchical, non-linear, dynamic
See also Oliver et al., Devred et al, Platt and
Sathyendranath,

EBVs: Regional habitat associations

biogeochemistry, diversity, fisheries habitat

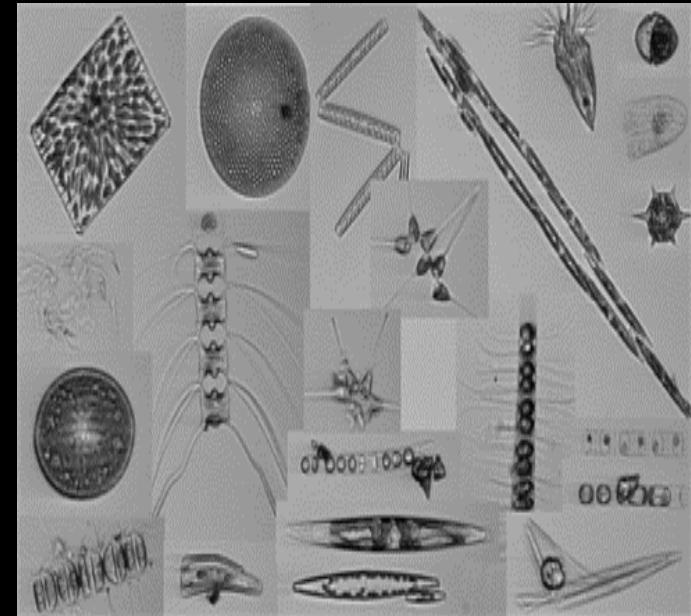
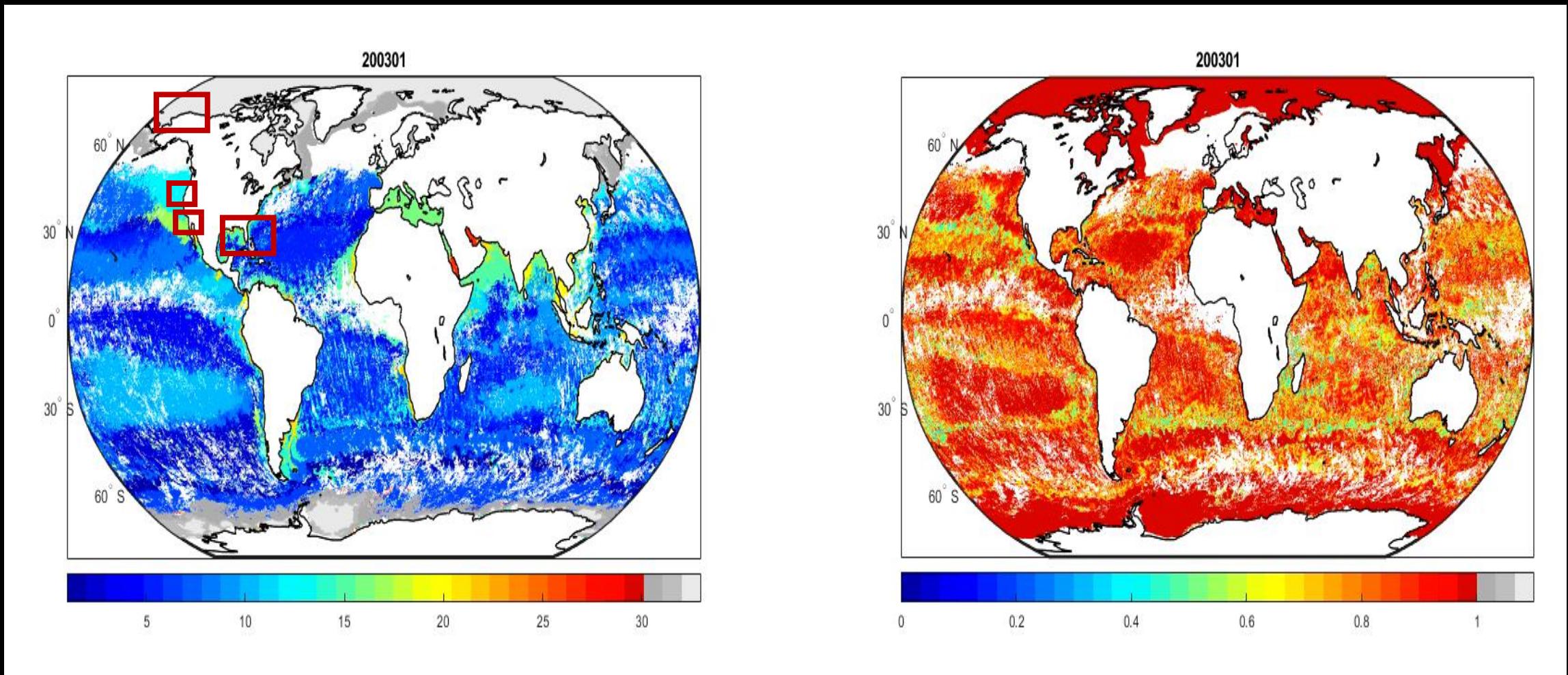


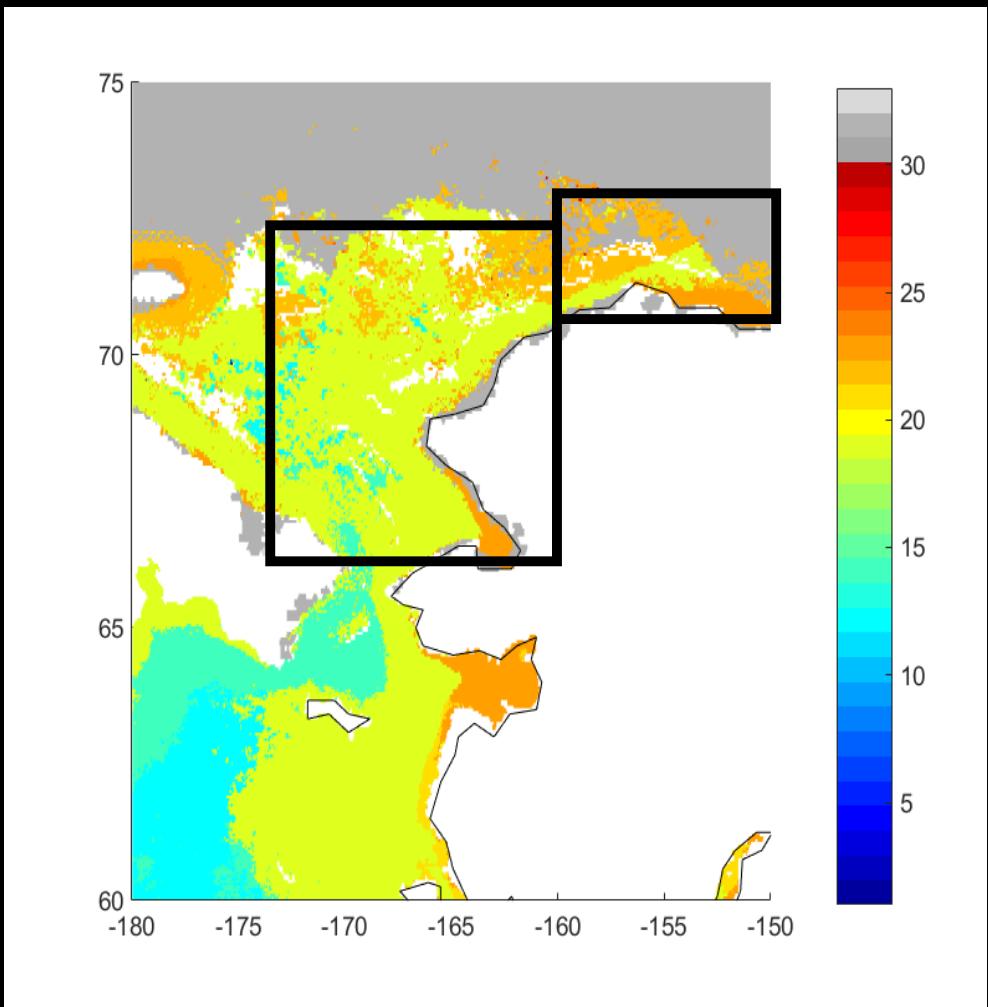
Photo Credit: Lisa Dilling
CINMS Image Library

Dynamic Seascapes framework: Comparison, rarefaction, methods comparison, seasonal and interannual habitat variability

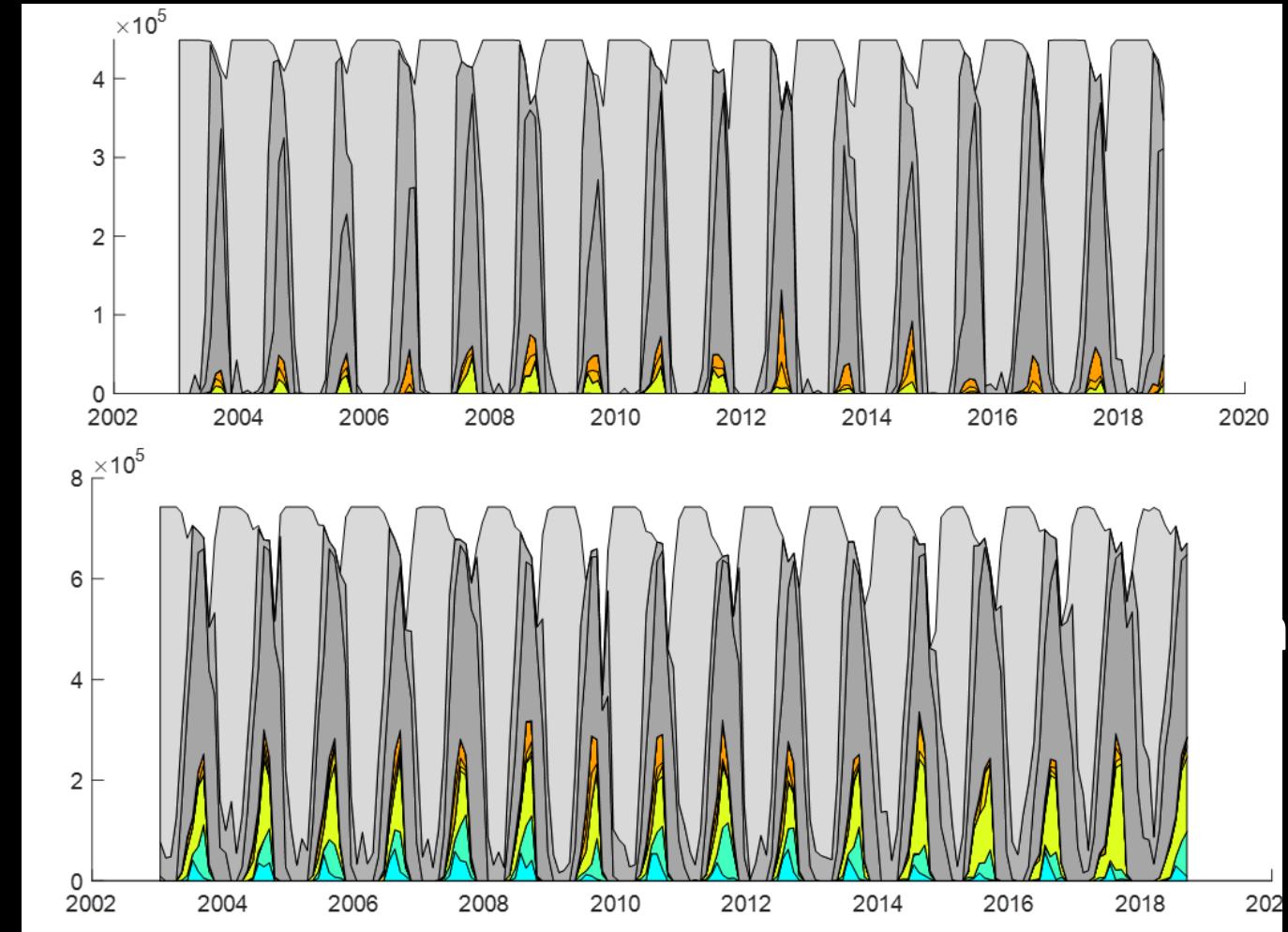


Method : attribution of uncertainty and the strength of ecotones or ecoclines (frontal regions).

Regional Case Study: Arctic Marine Biodiversity Observing Network

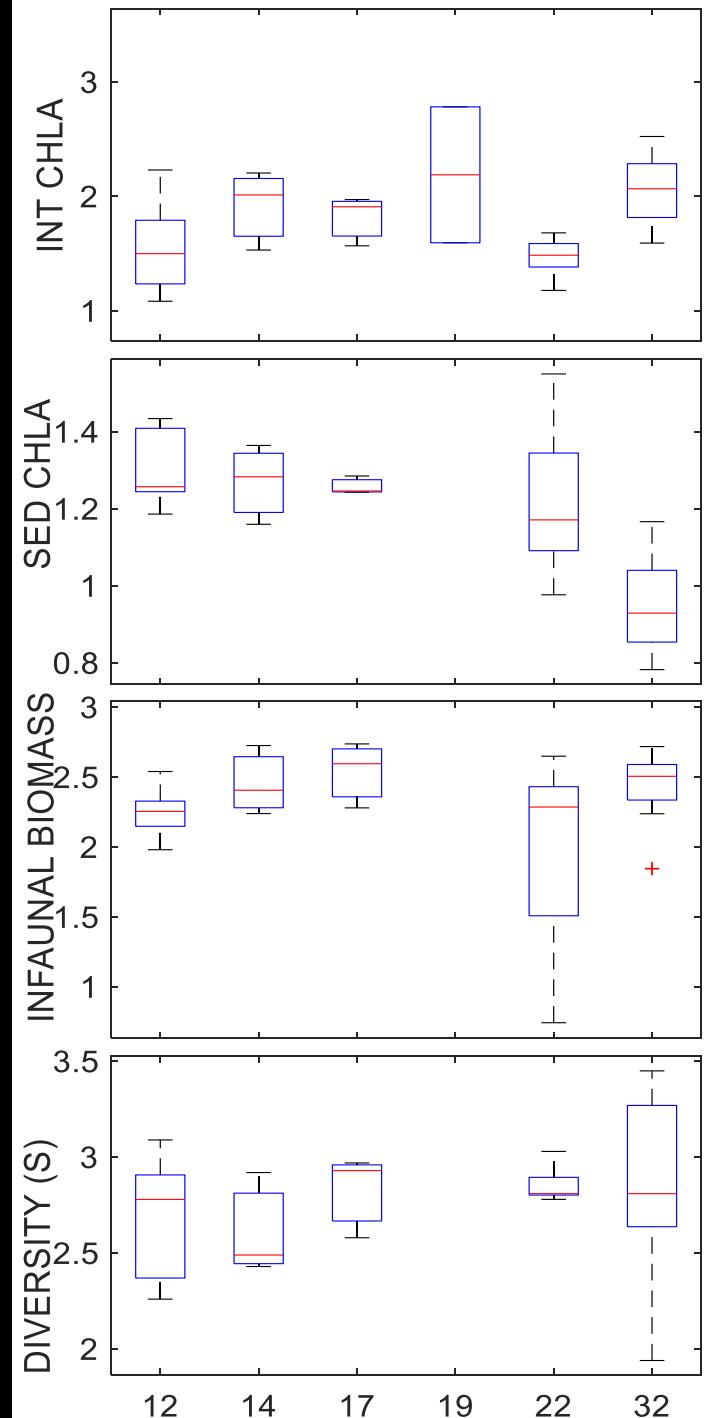
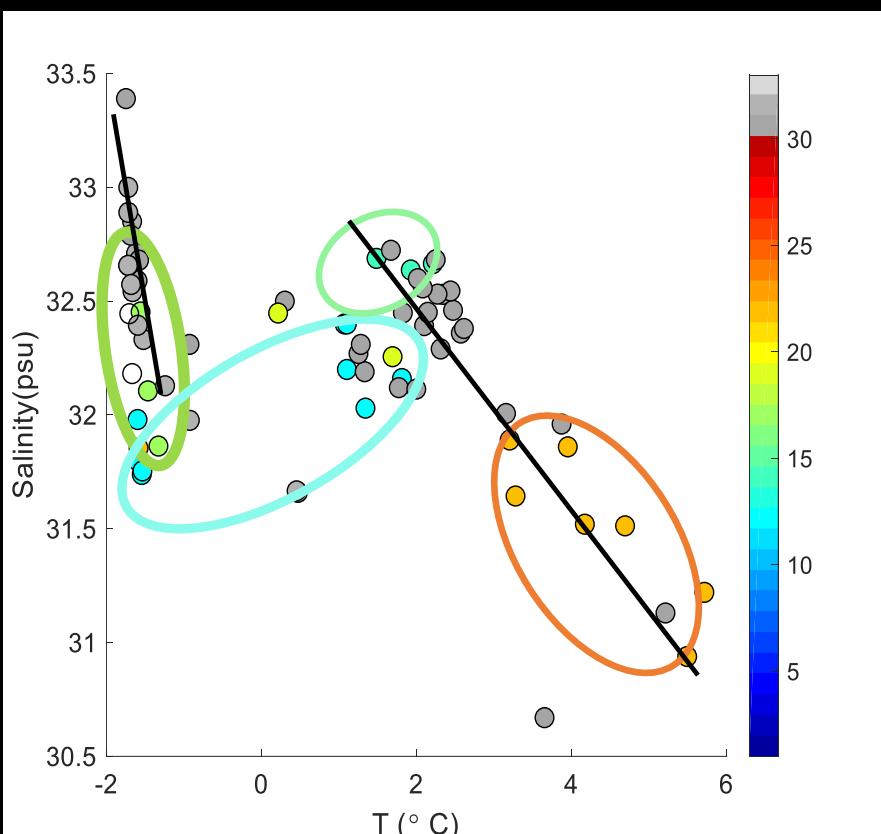
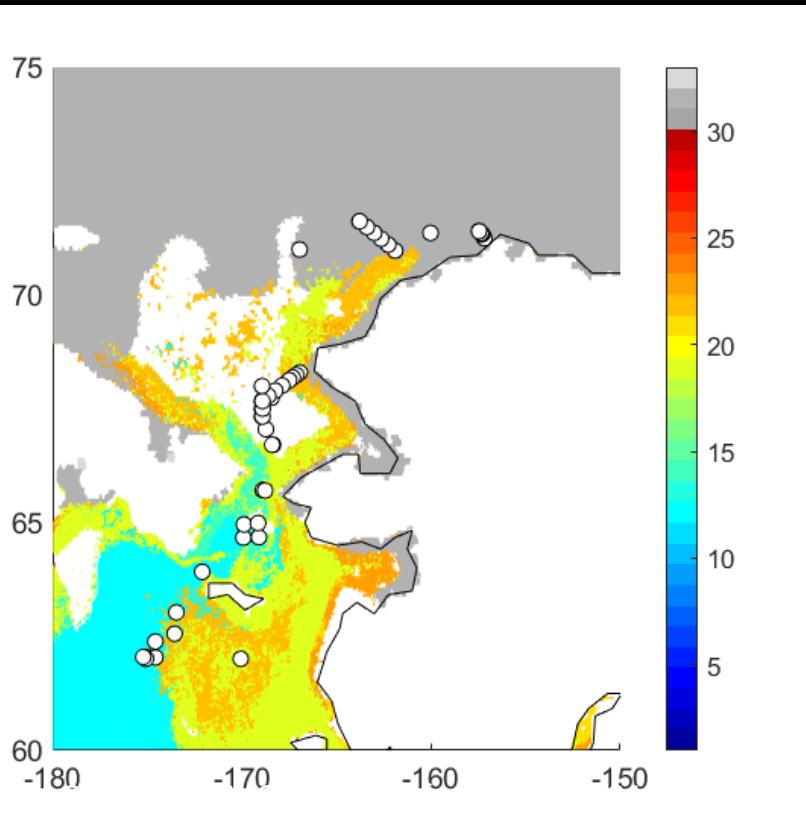


Dominant Seascape: Spatial Variability

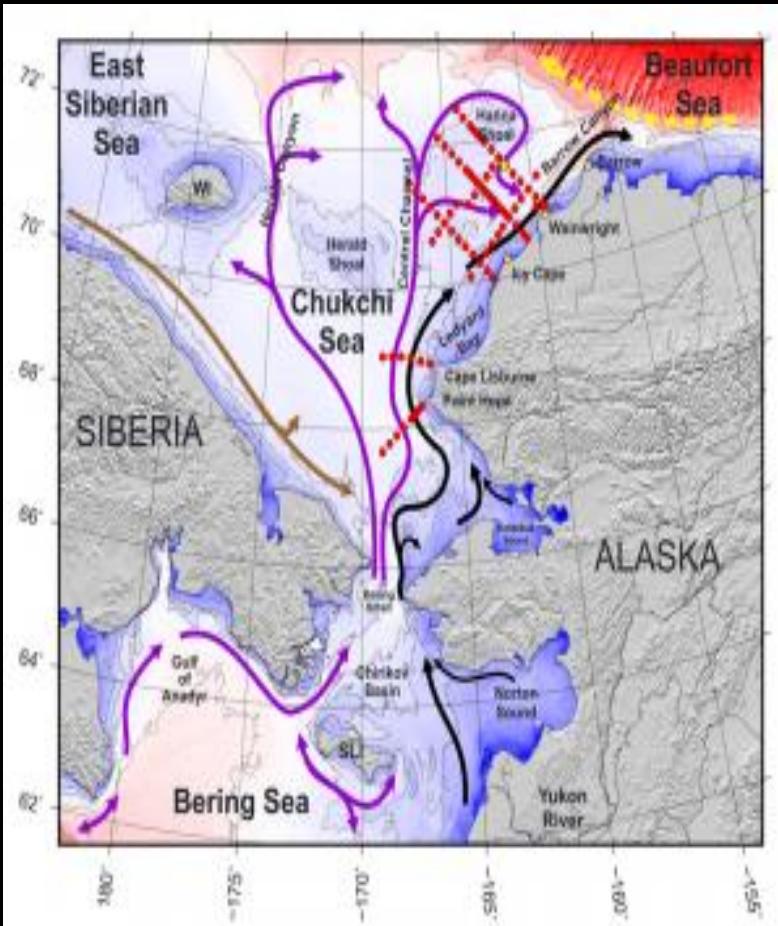


Areal extent of habitat in Beaufort (top) and Chukchi (bottom)

Distributed Biological Observatory: Do satellite seascapes detect meaningful benthic patterns?



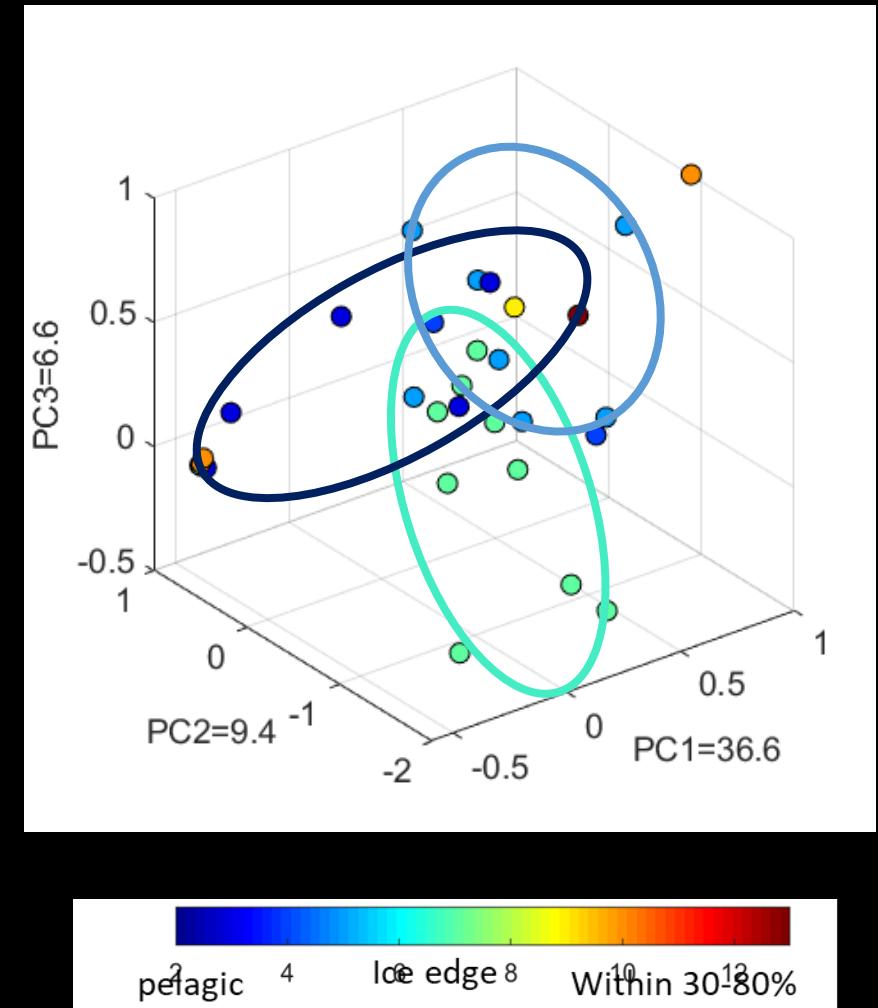
Regional Case Study: Arctic Marine Biodiversity Observing Network



Dataset: Zooplankton
community structure
2008-2015

- 174 Unique Taxa
- ~1800 samples

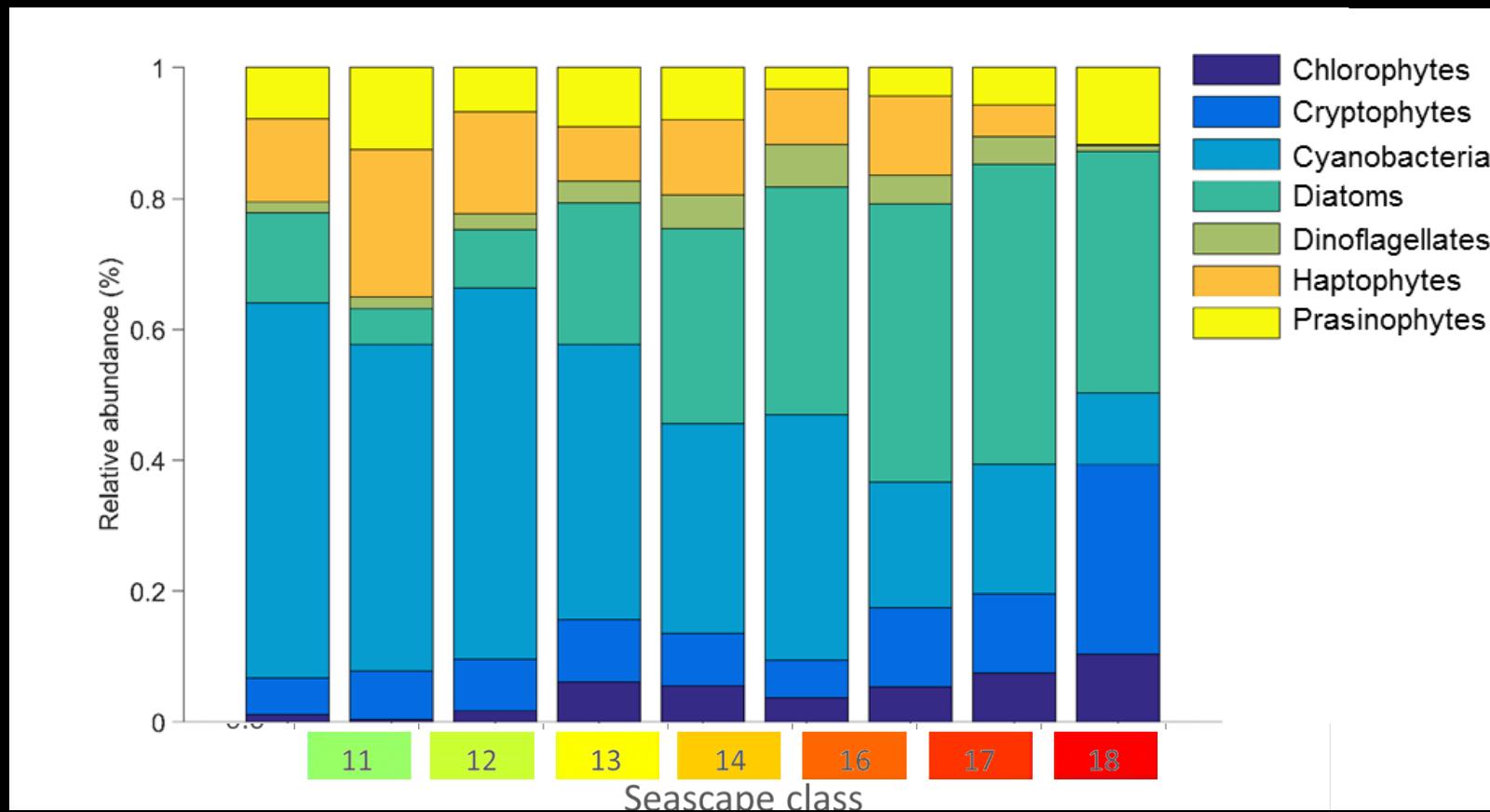
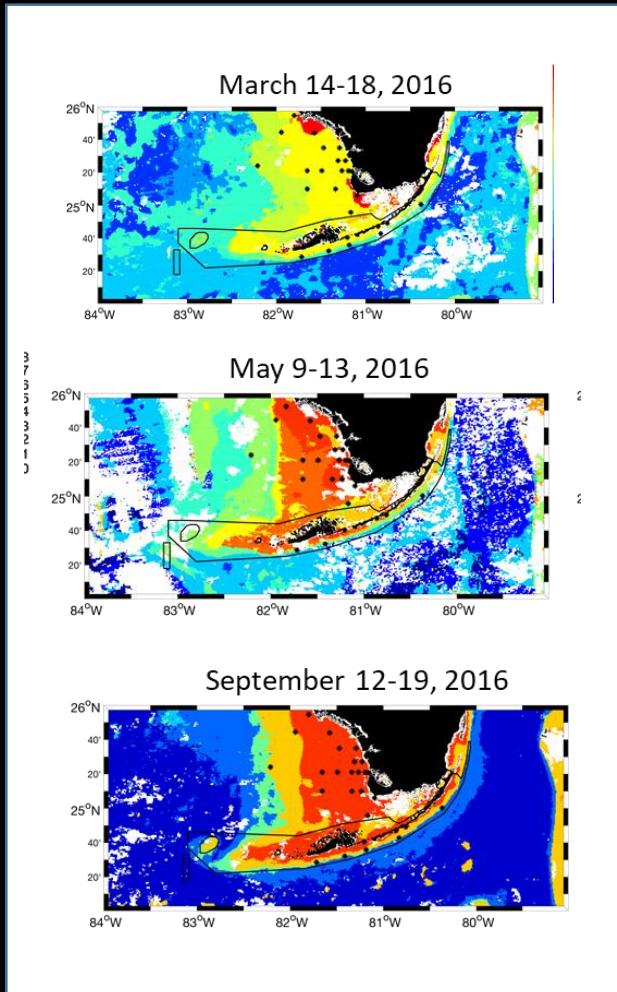
Current analysis: 0-50 m
150 mesh, Septembers



Florida: Seascapes plan ship-based studies & describe unique microplankton assemblages

Florida Keys NMS:
RV Walton Smith

Phytoplankton community structure varies with seascape



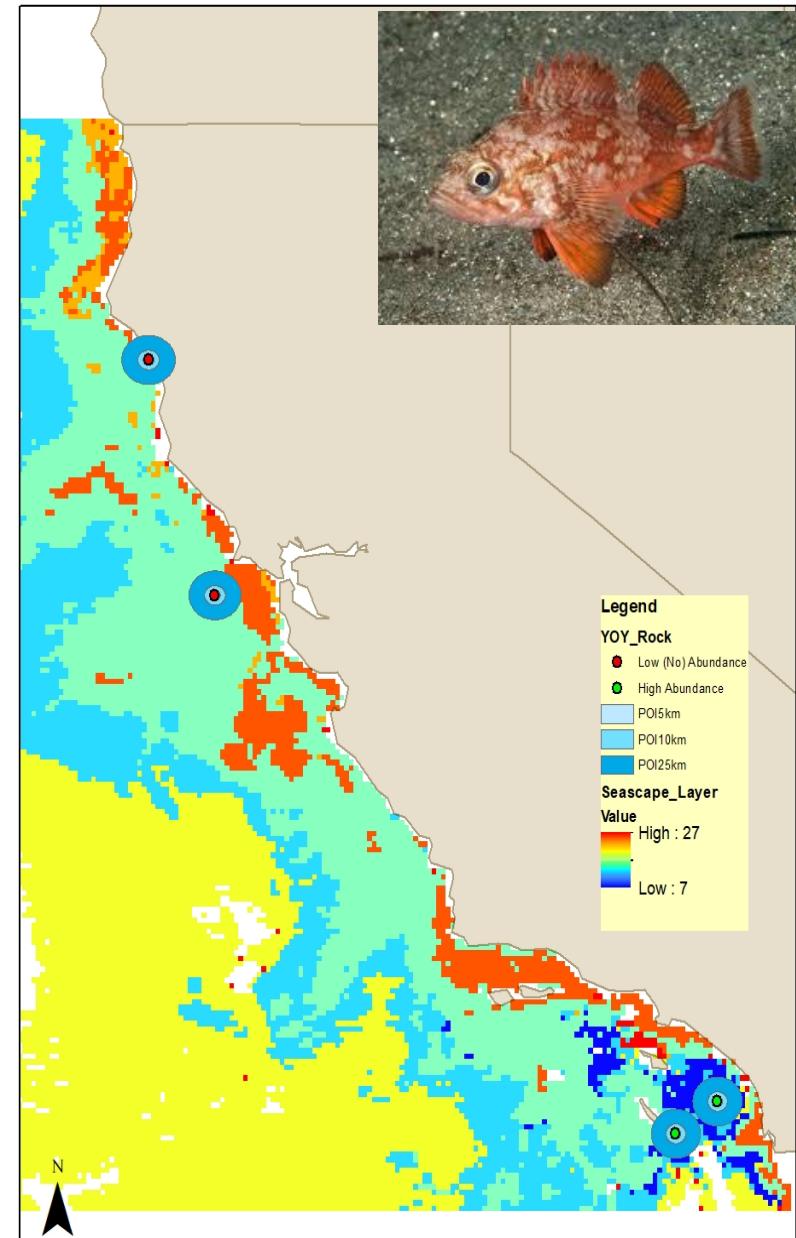
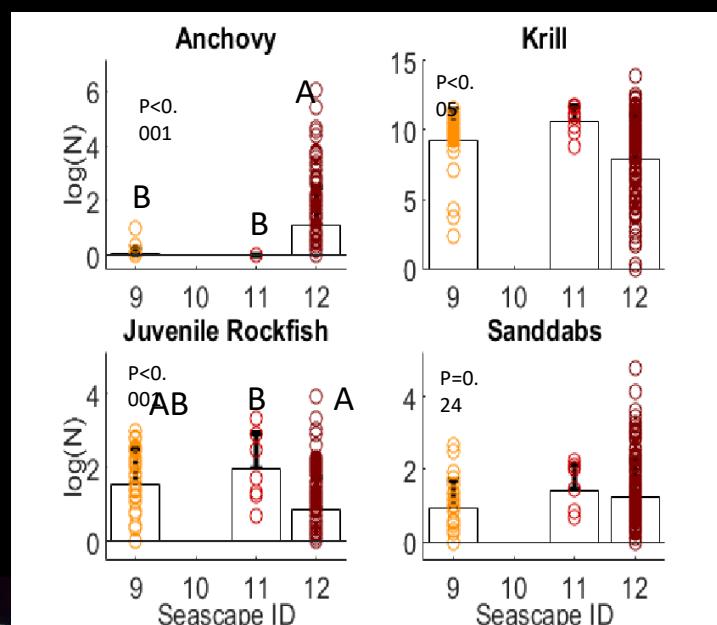
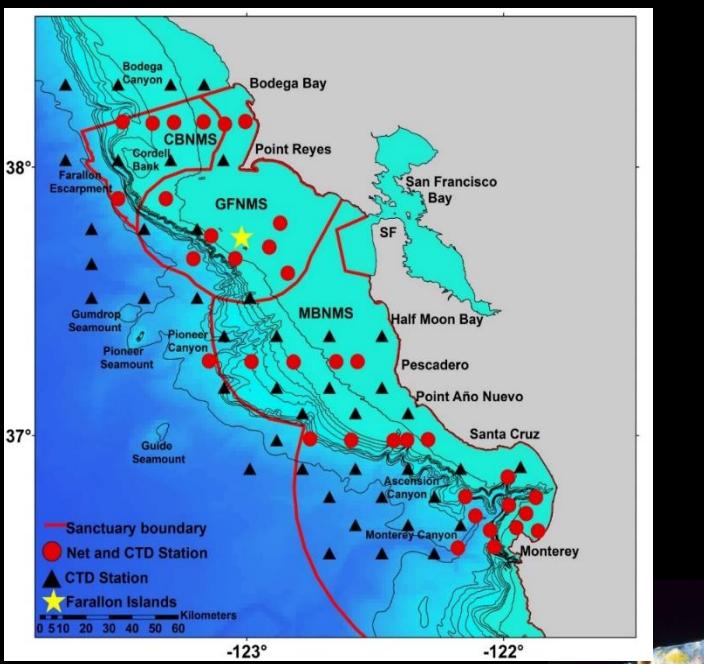
Enrique Montes et al., soon to be submitted

California: Seascapes as fish habitat indicator

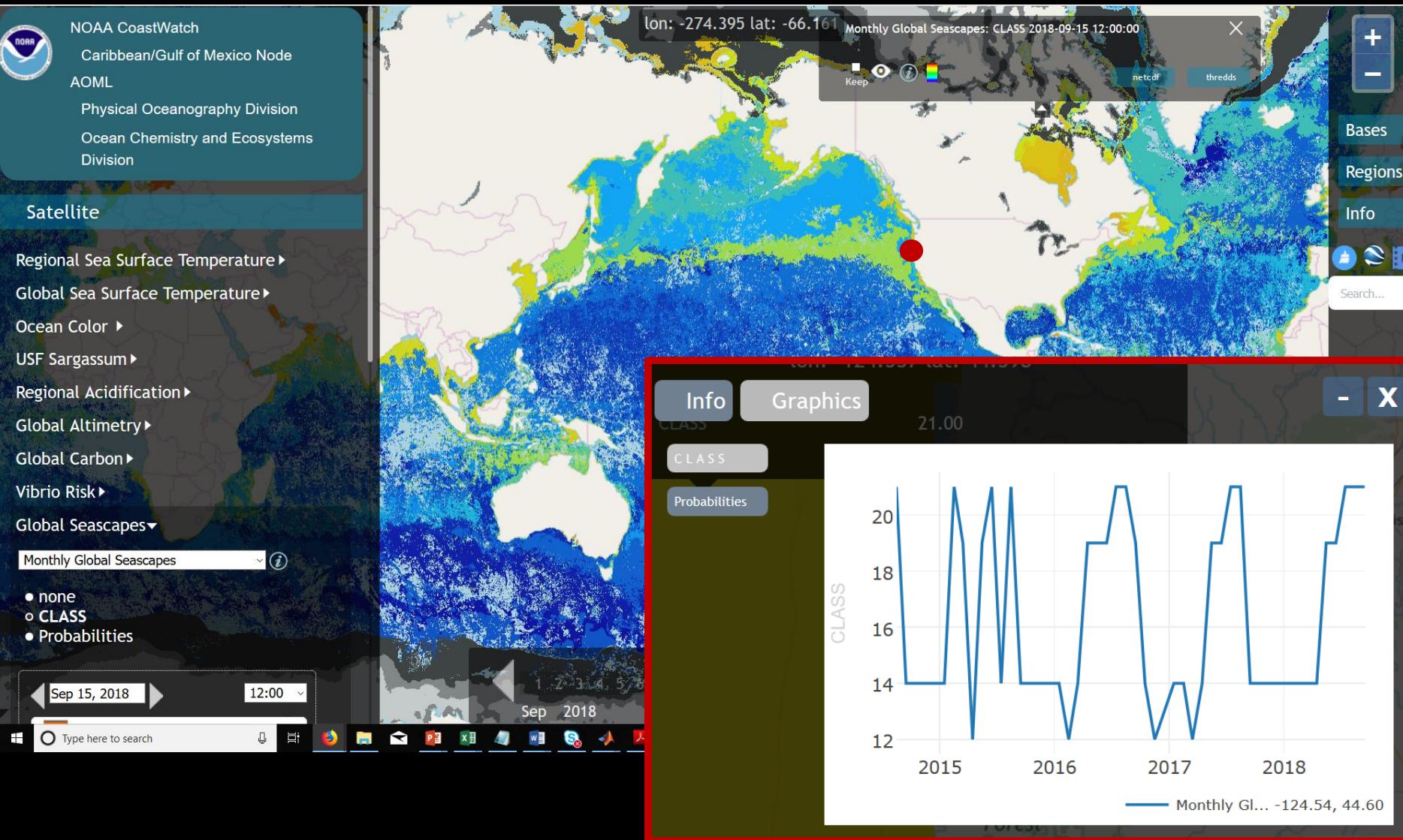
Forage fish abundance and occupancy across seascapes

Collaboration with NOAA Southwest Fisheries Science Center
Monterey Bay National Marine Sanctuary

Will Klabjor, Marine Resource Management MS



NOAA CoastWatch: Operational Global Coverage Seascapes Identity



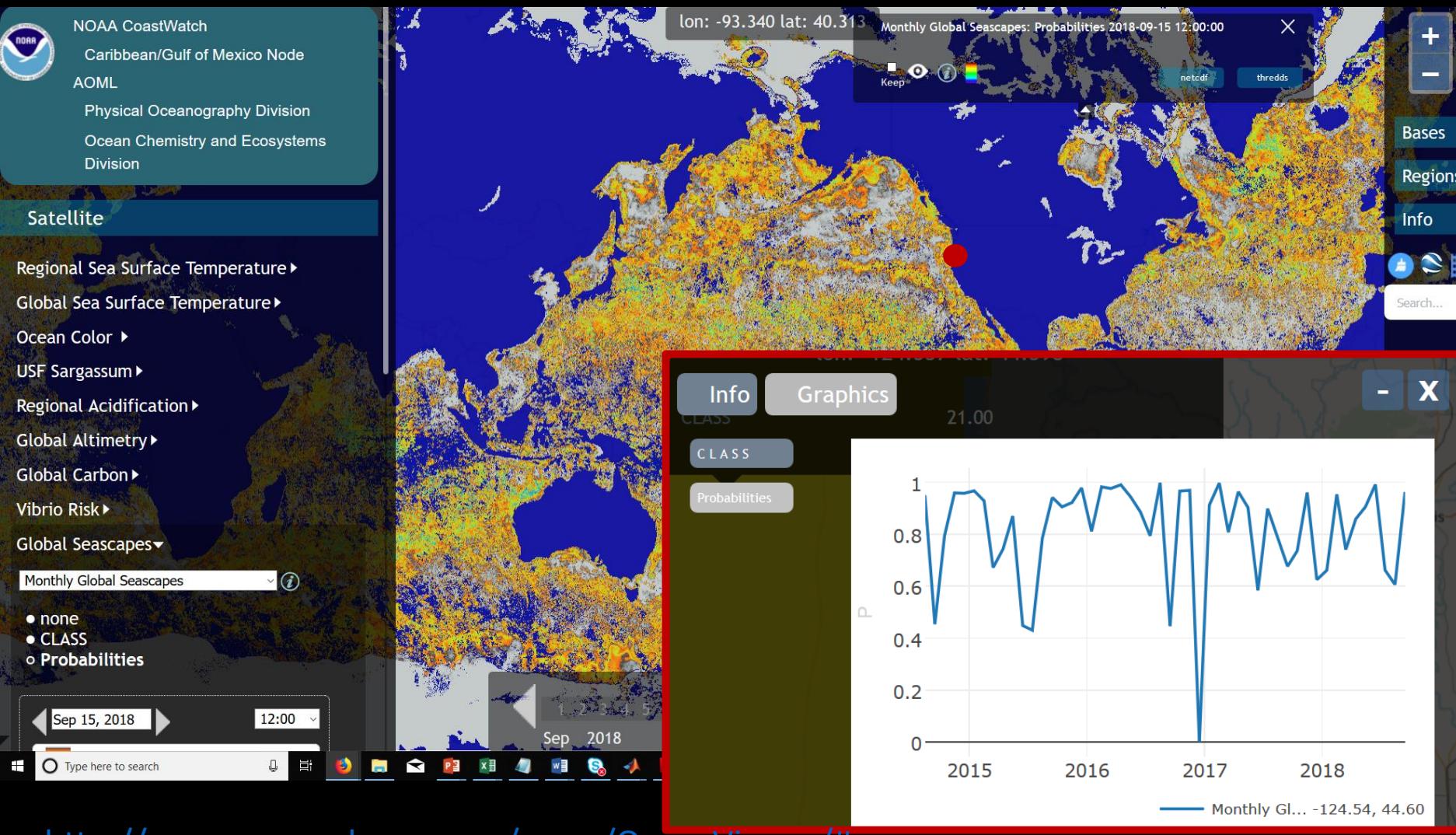
EBVs

Ecosystem Structure Class

- Habitat Structure
- Habitat Extent
- Habitat Function (time dynamics of seascapes identity)

Other Classes:
Community Composition
Ecosystem Structure

NOAA CoastWatch: Operational Global Coverage Seascapes Uncertainty



Science and Management

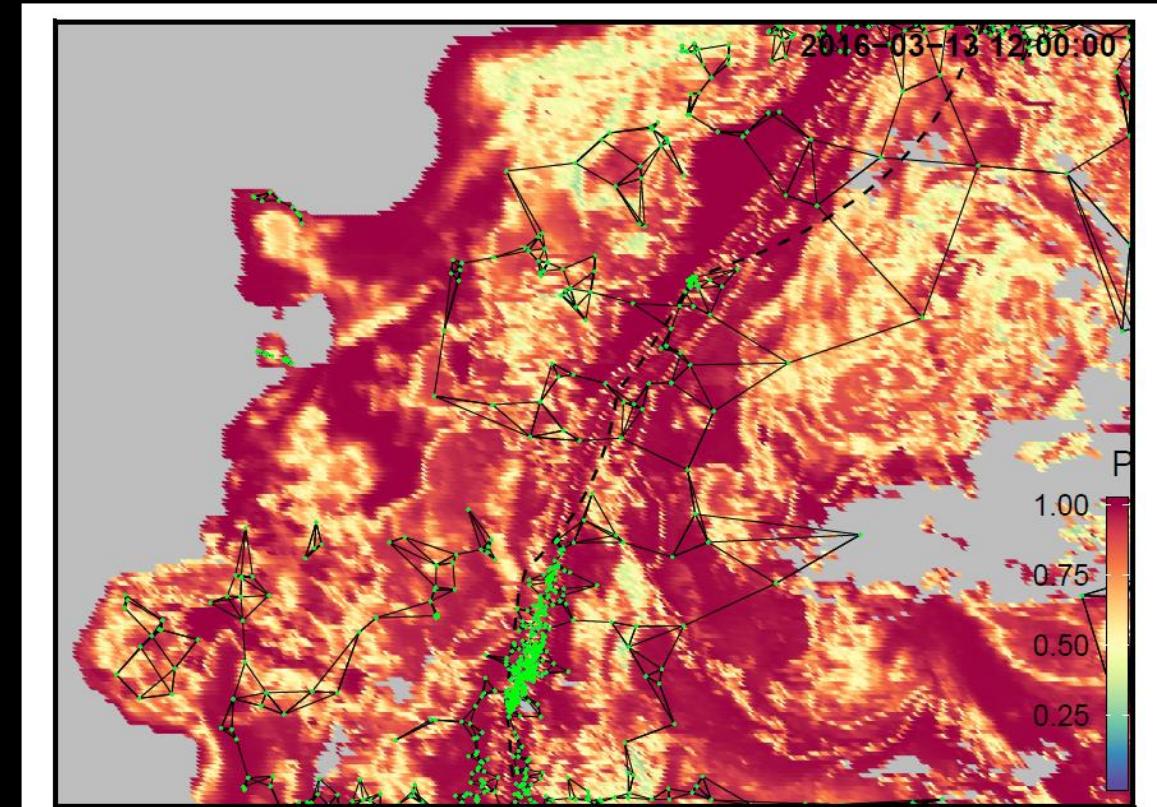
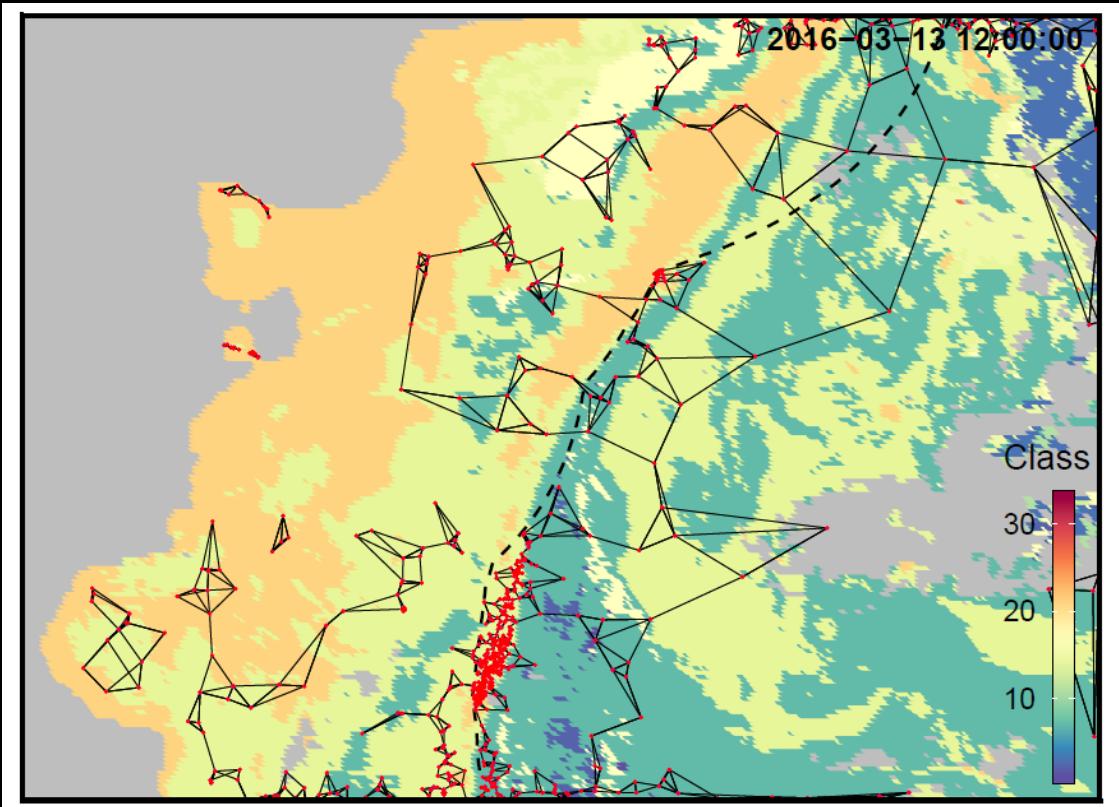
How well is the system characterized? How do we quantify atypical?

Where do we need better/more in situ data to classify habitat?

Anticipating Illegal, Unreported, Unregulated (IUU) Activities: James Watson, John Woodill OSU



Does the fleet respond to dynamic features?

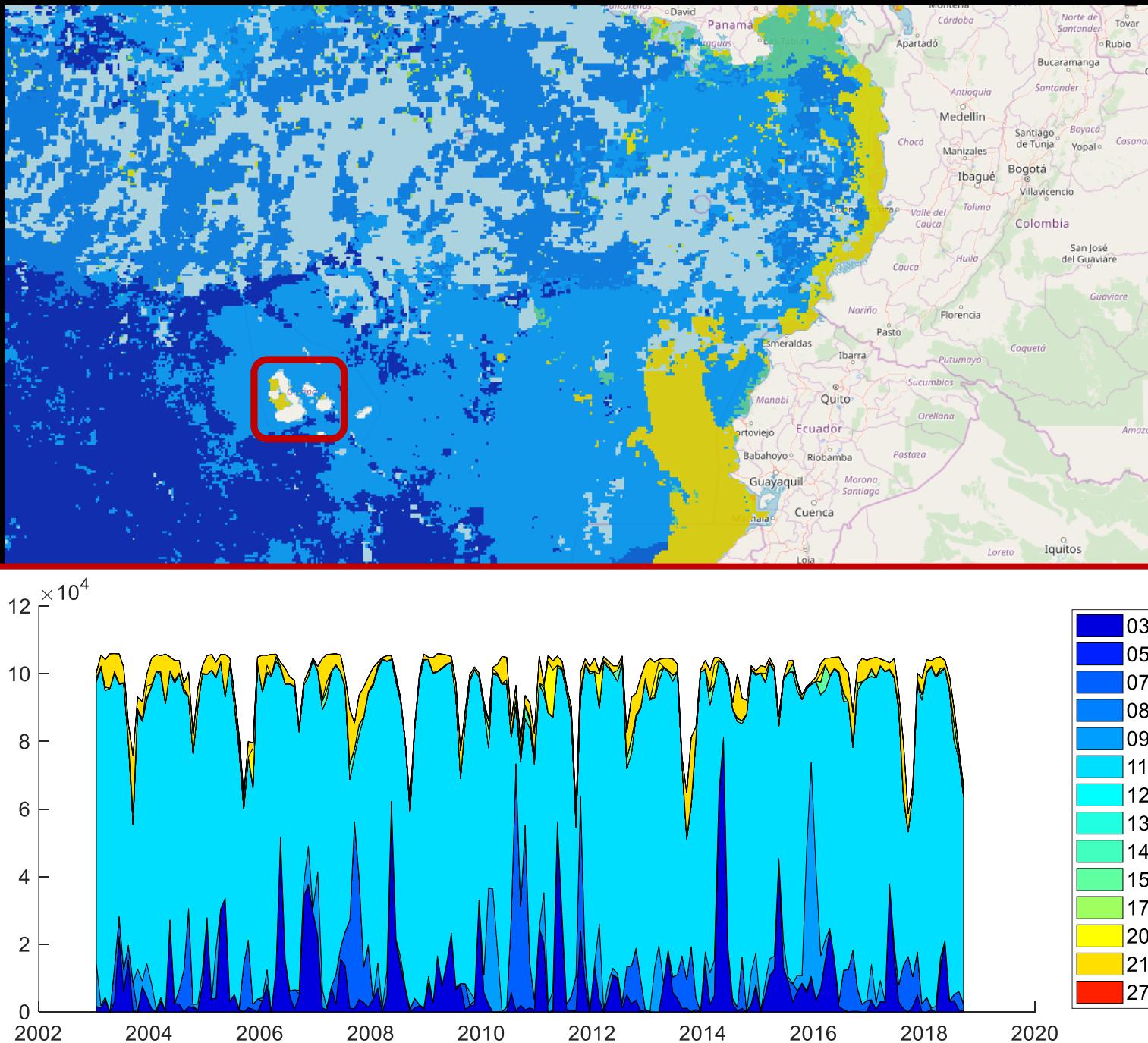


MBON Pole to Pole

Montes et al.

Littoral zone biodiversity monitoring across Americas

Community of Practice: sharing and synthesis
Building access and understanding of ocean remote sensing
Science informing management (re-zoning of Galapagos marine reserves)



Dynamic seascapes: global M(arine)-BON

Satellite-derived seascapes provide a metric of pelagic habitat geography (extent, location, representativeness) to inform spatial management of ecosystems across globe.

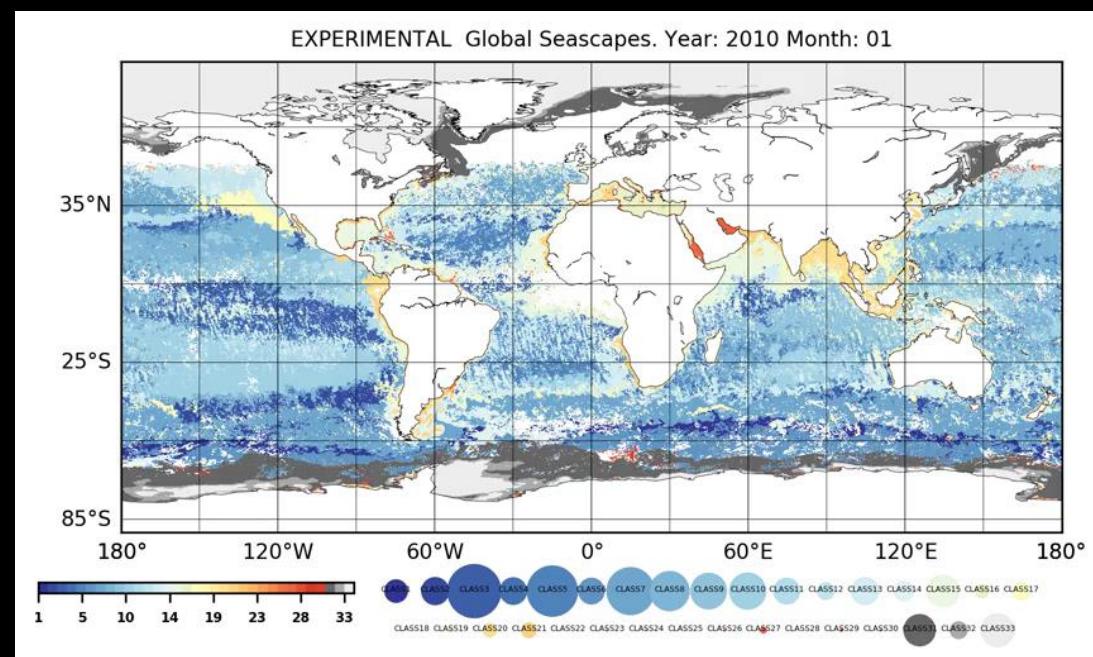
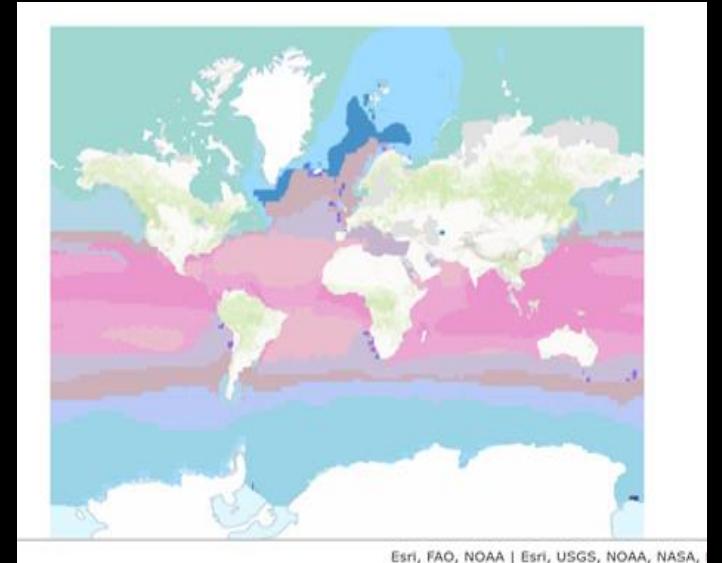
We continue to test hypotheses across ecosystems, trophic levels, occupancy metrics, and species distribution models.

Partnership with ESRI/USGS for EMU seascape comparison
(Vertical dimension is important!!!)

Real-time monitoring and adaptive management: Axiom and NOAA Coastwatch, MBON Explored, and NASA COVERAGE

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Ecological Marine Units
Static+3D



Time evolution of Seascapes

NOAA CoastWatch: multiscale and sustainable

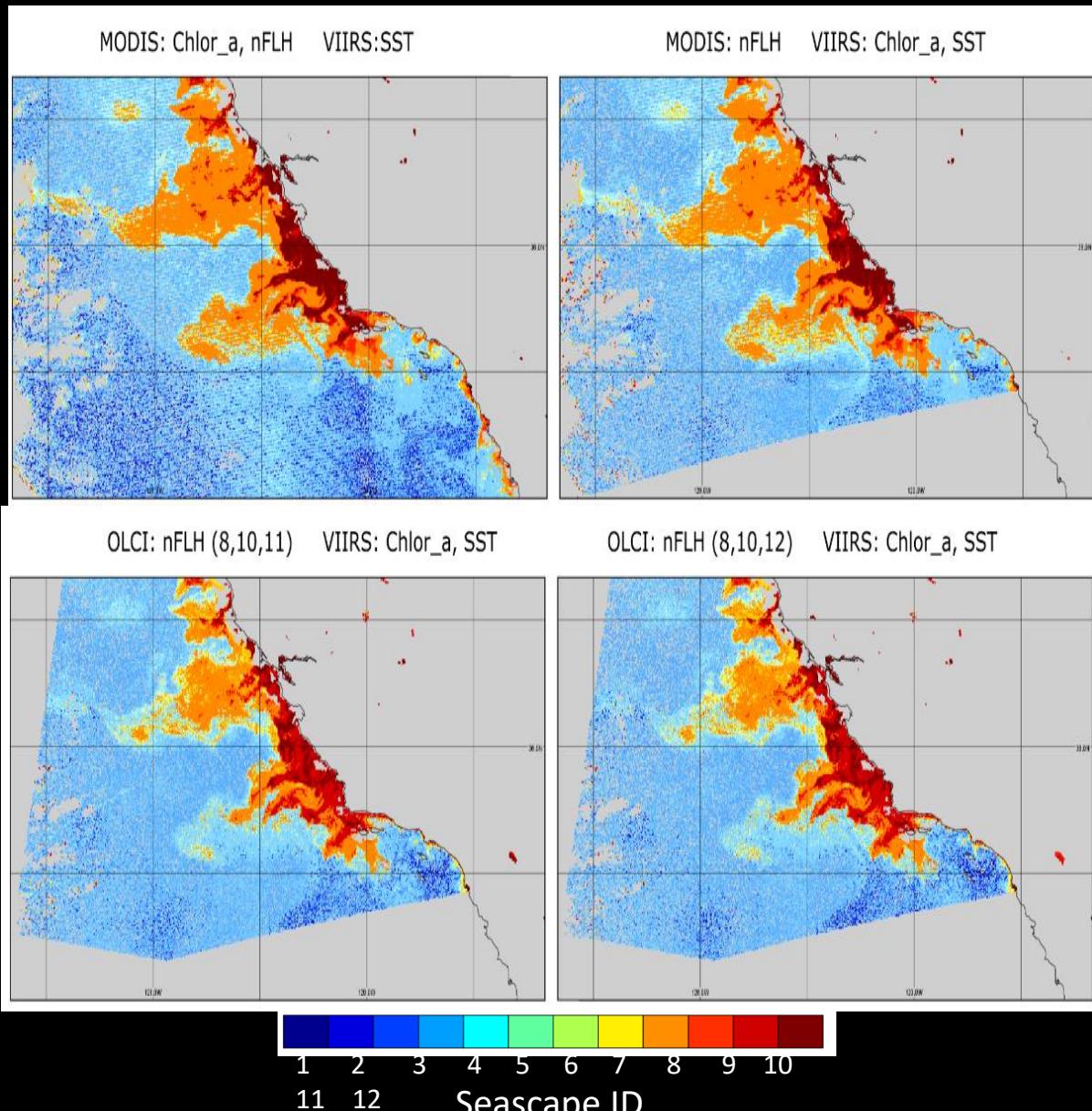
Continuity:

Comparisons between MODIS and VIIRS have been excellent

Opportunity for local downscaling case studies

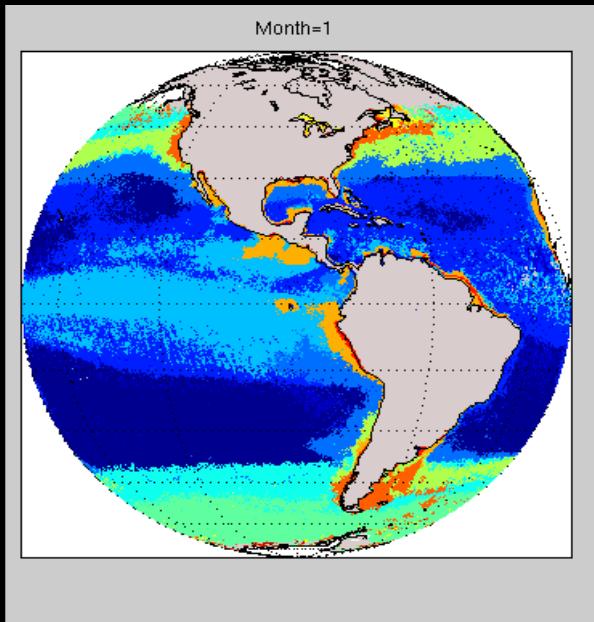


Paul DiGiacomo, Michael Sarocco and Joaquin Trinanes

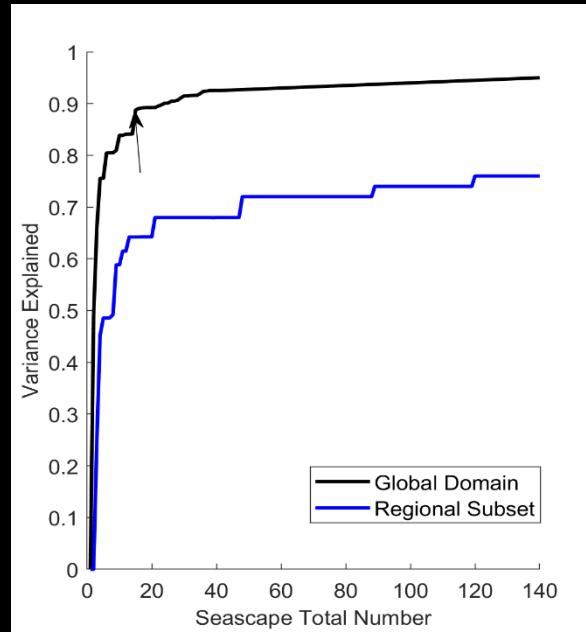


Global to regional trends: local variability and local products

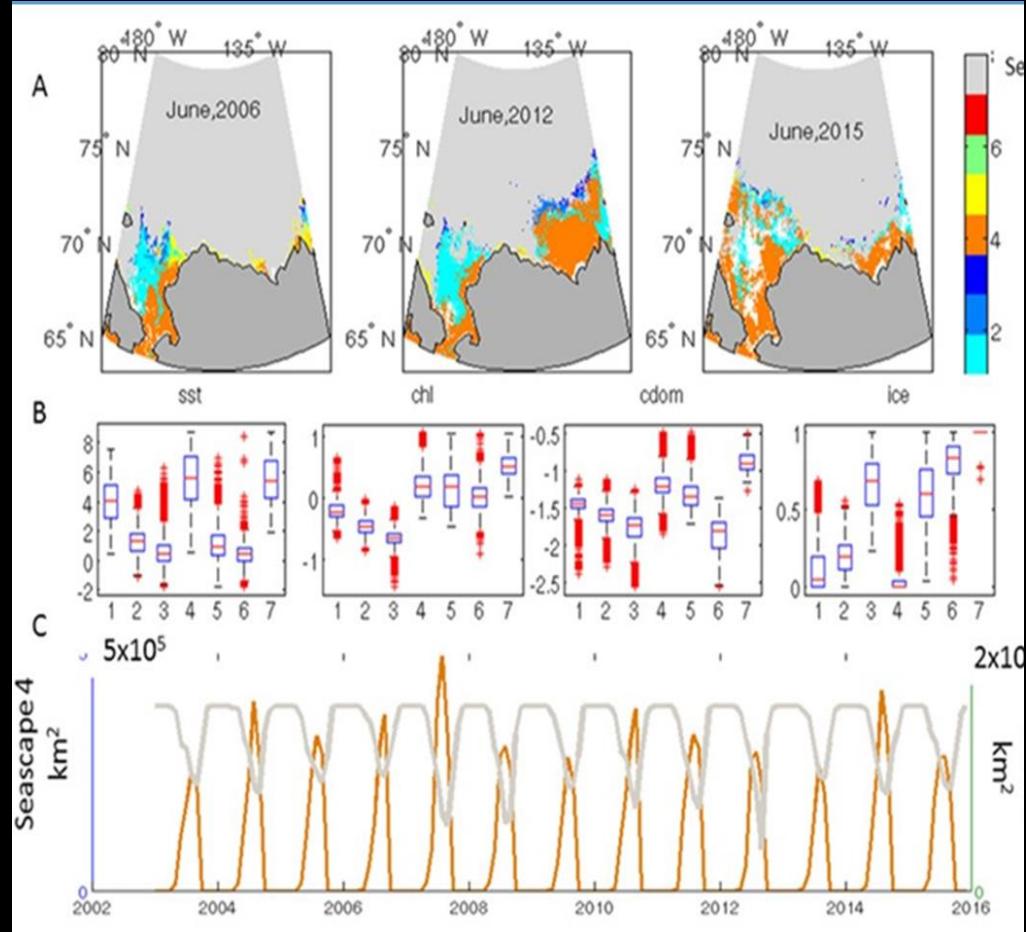
Global classification



Systematic Hierarchical Downscaling



Regional dynamic maps



- Globally relevant variables:
- SST, chl-a, nFLH, SSH, SSS
- Seasonal, >9km resolution
- N=15 – 30 (variable dependent)

- Sequential MANOVA:
regional domain using global
seascapes (gSS)
- 7 regional SS (70%) > 20 gSS
- 12 regional SS (75%) > 50 gSS

SEASCAPE ID NUMBER	NOMINAL DESCRIPTOR	SST (°C)	SSS (psu)	ADT (m)	ICE (%)	CDOM (m^-1)	CHLA (mg m^-3)	NFLH (W m^-2 um^-1 sr^-1)	NFLH:CHL	LATITUDE	DOMINANT HEMISPHERE	DOMINANT SEASON
1	NORTH ATLANTIC SPRING, ACC TRANSITION	5.08	34.18	-0.37	0	0.01	0.21	0.08	0.37	SUBPOLAR	SOUTH	SPRING-AUTUMN
2	SUBPOLAR TRANSITION	12.23	34.43	0.5	0	0.01	0.12	0.06	0.51	TEMPERATE	SOUTH	YEAR ROUND
3	TROPICAL SUBTROPICAL TRANSITION	24.12	35.34	0.68	0	0.01	0.15	0.06	0.4	TROPICAL	BOTH	YEAR ROUND
4	WESTERN WARM POOL SUBTROPICAL	28.25	34.4	1.1	0	0	0.06	0.05	0.79	SUBTROPICAL	BOTH	AUTUMN
5	SUBTROPICAL GYRE TRANSITION	23.95	35.89	0.71	0	0	0.07	0.04	0.5	SUBTROPICAL TEM	BOTH	AUTUMN-WINTER
6	ACC, NUTRIENT STRESS	1.38	34.01	-1	0	0.01	0.18	0.07	0.42	SUBPOLAR POLAR	SOUTH	WINTER
7	TEMPERATE TRANSITION	12.98	34.72	0.37	0	0.01	0.28	0.11	0.41	TEMPERATE	BOTH	WINTER
8	INDOPACIFIC SUBTROPICAL GYRE	25.13	34.52	0.99	0	0	0.07	0.02	0.34	SUBTROPICAL	BOTH	YEAR ROUND
9	EQUATORIAL TRANSITION	28.01	33.84	0.86	0	0.01	0.14	0.05	0.37	TROPICAL	BOTH	YEAR ROUND
10	HIGHLY OLIGOTROPHIC SUBTROPICAL GYRE	23.85	35.64	0.87	0	0	0.04	0.03	0.79	SUBTROPICAL	SOUTH	SUMMER
11	TROPICAL/SUBTROPICAL UPWELLING	22.94	34.79	0.83	0	0.01	0.27	0.11	0.39	TROPICAL,SUBTRO	BOTH	WINTER
12	SUBPOLAR	8.62	32.91	0.3	0	0.02	0.37	0.08	0.22	TEMPERATE/SUBP	BOTH	YEAR ROUND
13	SUBTROPICAL GYRE MESOSCALE INFLUENCED	23.47	35.89	0.52	0	0.01	0.1	0.02	0.19	SUBTROPICAL TEM	BOTH	SPRING-SUMMER
14	TEMPERATE BLOOMS UPWELLING	9.95	33.91	-0.01	0	0.03	0.84	0.16	0.19	TEMPERATE/SUBP	BOTH	SPRING SUMMER
15	TROPICAL SEAS	25.35	35.4	0.51	0	0.02	0.32	0.06	0.2	TROPICAL/SUBTRC	BOTH	WINTER
16	MEDITTERANEAN RED SEA	18.74	37.87	0.03	0	0.02	0.22	0.05	0.22	SUBTROPICAL/TEN	NORTH	WINTER
17	SUBTROPICAL TRANSITION LOW NUTRIENT STRESS	20.89	33.59	0.64	0	0.01	0.17	0.02	0.15	TROPICAL/SUBTRC	NORTH	SUMMER
18	MEDITTERANEAN RED SEA	21.94	37.72	-0.05	0	0.01	0.11	0.01	0.1	TEMPERATE/SUBP	BOTH	SPRING-SUMMER
19	ARTIC/ SUBPOLAR SHELVES	7.63	31.55	0.15	0	0.05	1.19	0.11	0.09	TEMPERATE/SUBP	BOTH	YEAR ROUND
20	SUBTROPICAL, FRESH INFLUENCED COASTAL	27.45	31.82	0.88	0	0.02	0.34	0.06	0.18	SUBTROPICAL	NORTH	WINTER/YEAR-ROUND
21	WARM, BLOOMS, HIGH NUTS	22.54	34.46	0.57	0	0.07	2.09	0.24	0.12	TROPICAL/SUBTRC	BOTH	WINTER/YEAR-ROUND
22	ARCTIC LATE SUMMER	6.26	30.1	-0.09	0.43	0.03	0.47	0.03	0.06	SUBPOLAR/POLAR	NORTH	SUMMER
23	FRESHWATER INFLUENCED POLAR/SUBPOLAR SHELVES	8	27.74	0.11	1	0.05	1.16	0.06	0.05	SUBPOLAR/POLAR	NORTH	SUMMER
24	ANTARCTIC SHELVES	0.23	33.84	-1.11	18.62	0.01	0.32	0.1	0.3	SUBPOLAR/POLAR	SOUTH	SPRING SUMMER
25	ICE PACK/LARGE POLYNAS	0.8	30.64	-0.38	62.24	0.02	0.51	0.06	0.12	SUBPOLAR/POLAR	BOTH	SPRING SUMMER
26	ANTARCTIC ICE EDGE	0.26	33.58	-0.97	34.35	0.01	0.4	0.11	0.27	POLAR	SOUTH	SUMMER
27	HYPERSALINE EUTROPHIC, PERSIAN GULF, RED SEA	25.95	38.14	0.54	0	0.07	1.15	0.11	0.09	SUBTROPICAL /TEM	NORTH	WINTER/YEAR-ROUND